EGU23-4515, updated on 15 Apr 2024
https://doi.org/10.5194/egusphere-egu23-4515
EGU General Assembly 2023

A glacio-hydrological perspective on the extreme year 2022 in Switzerland

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Summer 2022 broke numerous glaciological, hydrological and climatological records in Europe. Dry and warm conditions led to extreme low-water levels and problems with water supply. The hot summer in combination with little snow in winter was disastrous for the Swiss glaciers; they never lost as much volume in the century-long observational record. At the same time, this massive glacier melt meant an alleviation of the downstream hydrological drought situation. Glacier contributions to streamflow during hot and dry periods, as well as their changes due to glacier retreat are, however, poorly quantified.

In this study, we characterize the glacio-hydrometeorological extremeness of the hydrological year 2022 in Switzerland and compare it with other exceptional years in the past. Observational streamflow records from about 80 stations along glacier-fed rivers were analyzed, together with (i) temporally downscaled and spatially extrapolated glacier mass balance observations, as well as (ii) temperature and precipitation information. Results show that precipitation and temperature were exceptional, but there have been years since 1961 that were warmer or drier. However, the combined effect of low precipitation and high temperatures led to record-low summer flows throughout Switzerland, apart from the Rhone river, the upstream part of the Aare river, and a few high-elevation catchments. Catchments with a glacier cover of more than 20% even resulted in above normal summer streamflow in 2022.

The annual relative meltwater contribution from glacierized areas ranged from a few percent up to 80% of the total streamflow among the catchments and equaled up to double the mean contribution estimated for the period 1981-2010. Although 2022 glacier volume losses broke records, only a few catchments showed a record amount of glacier melt water contribution to streamflow. This may hint that for most catchments, glacier retreat is dominating the melt response to extreme warm conditions, instead of differences in the respective meteorological conditions. This process reduces the crucial capacity of glaciers to alleviate downstream drought conditions. Overall, the study highlights the need for an integrated analysis of meteorological, hydrological and glaciological data to understand the spatiotemporal dynamics of extreme dry and warm years.